

The Long Term Potential of the Modern Modular Bubble Chamber (MMBC)

Open Session for Remarks

Particle Physics Project Prioritization Panel (P5) Townhall

Fermilab & Argonne

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Project Management ([Notion](#))

Document Server ([Google Drive](#))

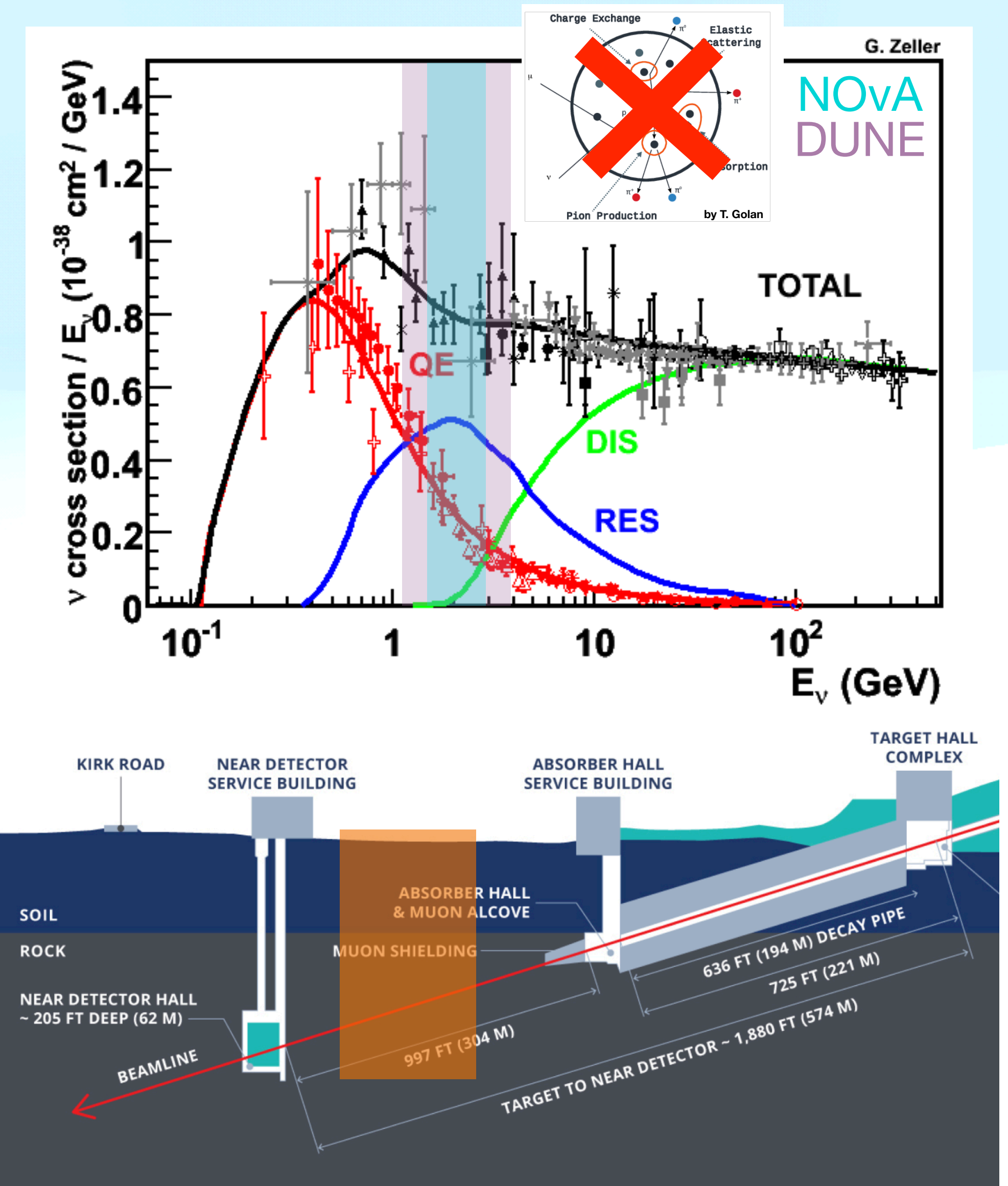
Meetings Thursdays at 10 AM CT



Enhancing Understanding of Cross Sections

Primary Concern of a Bubble Chamber with Light Nuclear Targets

- Primary goal of the Modern Modular Bubble Chamber project is to baseline the operational limits and safety costs of a ton scale bubble chamber device *with light nuclear targets*.
- Full scale device should yield about $\sim 10^5$ events per ton-year if used in the 1.2 MW LBNF beam.
- The **Modularity** of the device is a *key component* of its operation. Each module should be completely self contained with edge-sensing *at a minimum*. **Vertical Flux Deconvolution a la DUNE PRISM?**
- **Modularity** also concerns ability to use *multiple working fluids*.



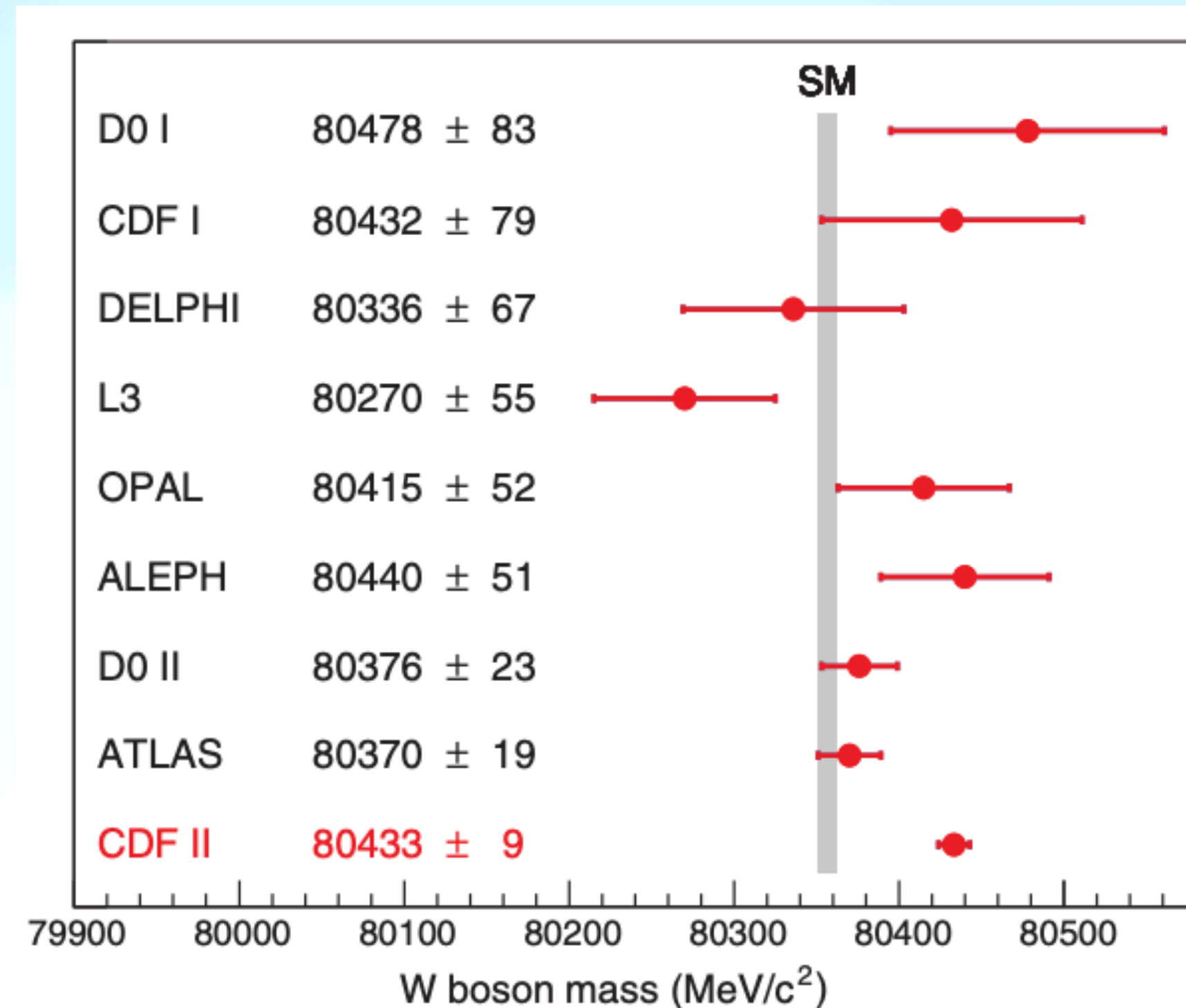
Simultaneous Contributions to BSM Searches

Revisiting a Controversial Measurement

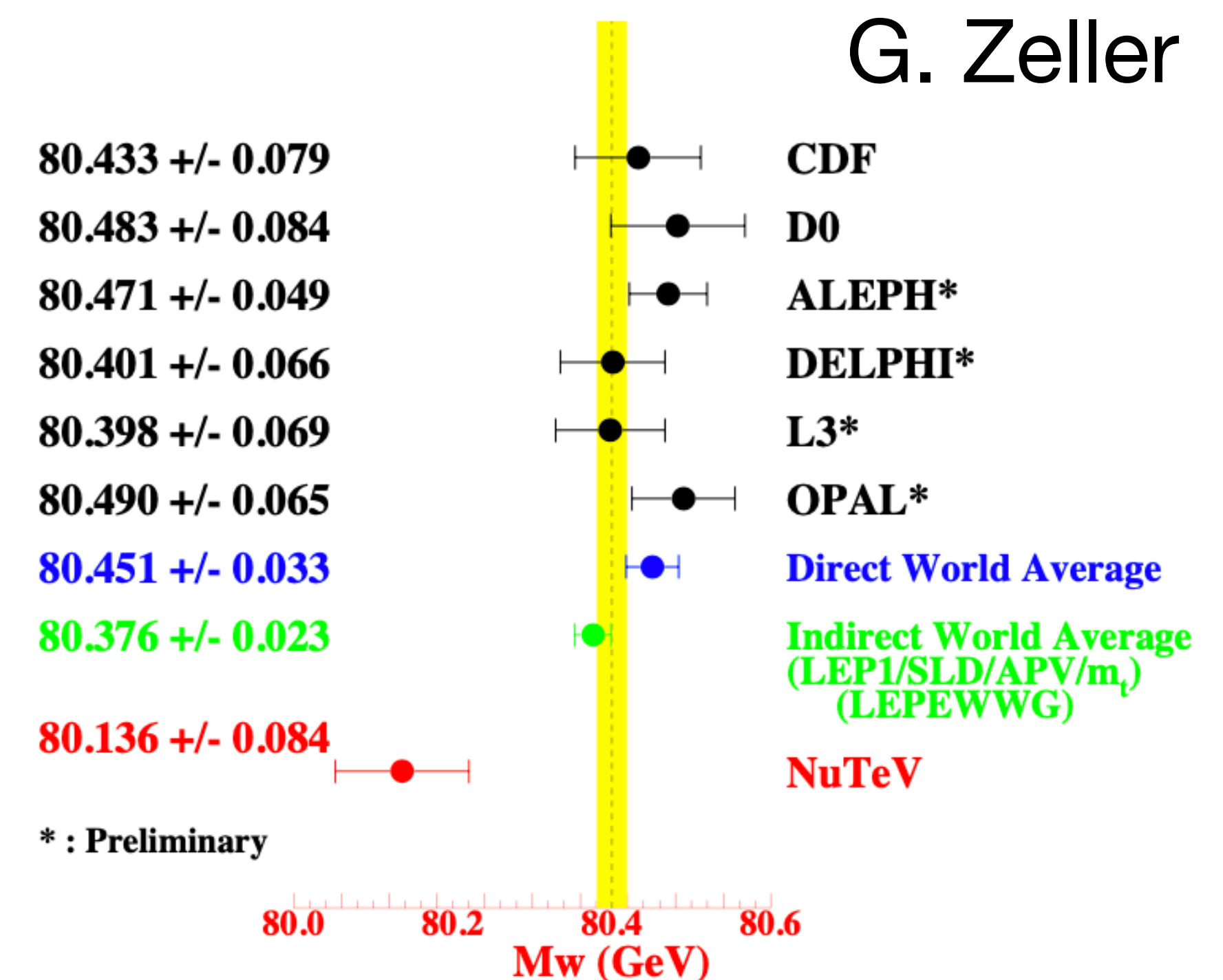
$$\sin^2 \theta_W = \frac{1}{2} - \left(\frac{m_W}{m_Z} \right)^2 = \frac{1}{2} - \frac{\sigma_{NC}^\nu - \sigma_{NC}^{\bar{\nu}}}{\sigma_{CC}^\nu - \sigma_{CC}^{\bar{\nu}}}$$

NuTeV Experiment measured the Paschos-Wolfenstein ratio on Fe through a comparison of CC to NC events for $\bar{\nu}/\nu$ and found a $\sim 3\sigma$ offset from the standard model.

Most recent look from CDF II is most precise recent measurement, how much can we contribute *without the effects of the nuclear medium*?



Science, 376, 6589, (2022)



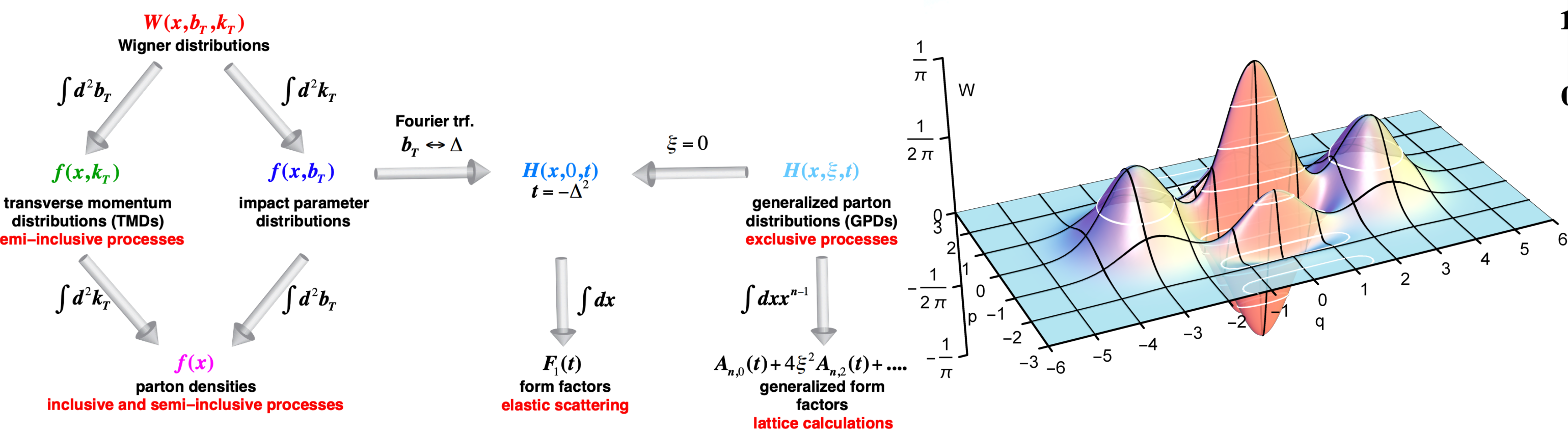
Simultaneous Contributions to Nucleon Structure

A Novel Probe with High Complement to the Electron Ion Collider

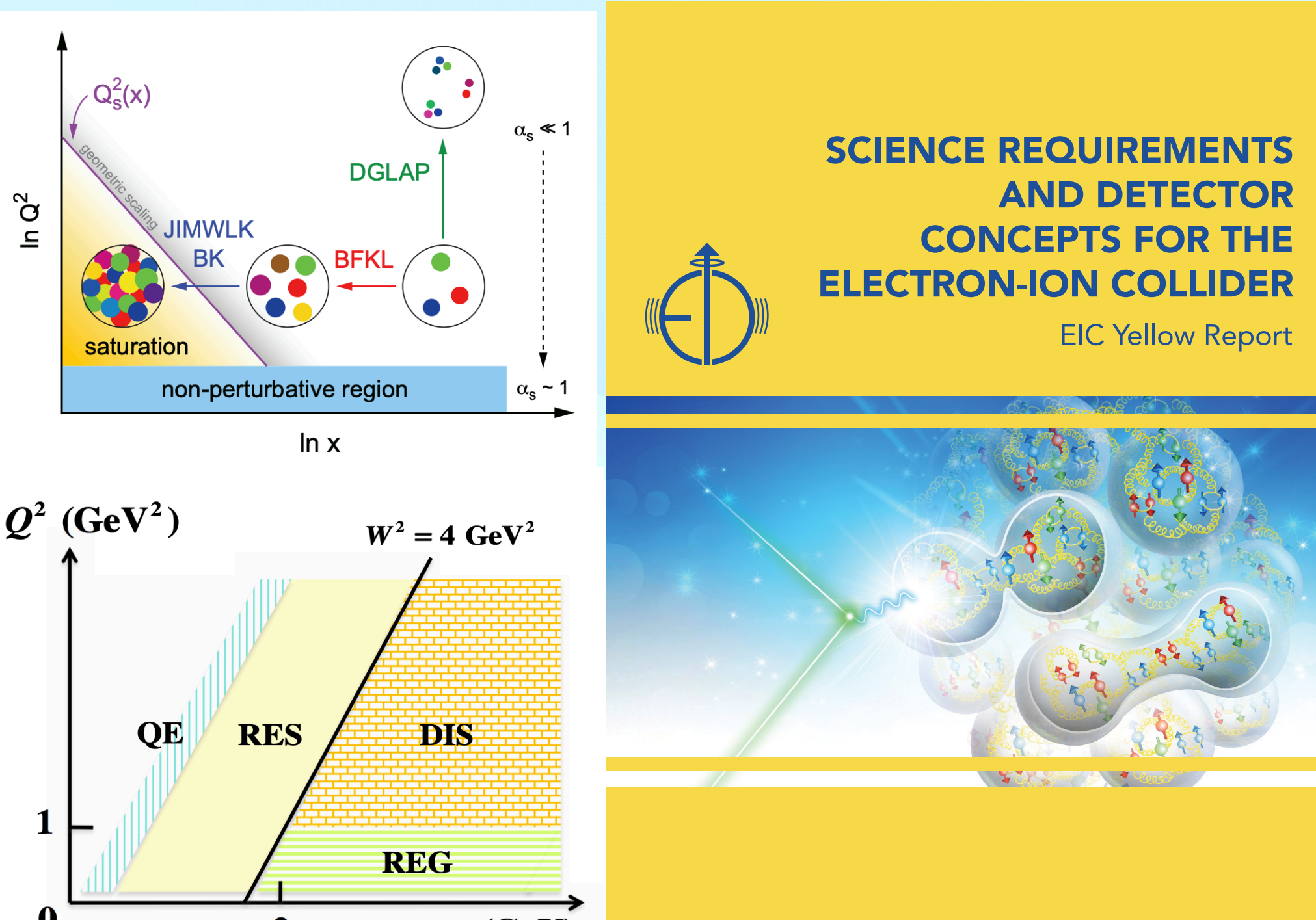
$$\frac{d\sigma_{CC}^{\nu/\bar{\nu}}}{dx dy} = \frac{G_F^2 s}{2\pi (1 + Q^2/M_W^2)^2} \left[F_1^{CC} x y^2 + F_2^{CC} \left(1 - y - \frac{Mxy}{2E} \right) \pm F_3^{CC} xy \left(1 - \frac{y}{2} \right) \right]$$

$$\begin{aligned} F_2^{\nu p(CC)} &= 2x (d + s + \bar{u} + \bar{c}), & xF_3^{\nu p(CC)} &= 2x (d + s - \bar{u} - \bar{c}), \\ F_2^{\bar{\nu} p(CC)} &= 2x (u + c + \bar{d} + \bar{s}), & xF_3^{\bar{\nu} p(CC)} &= 2x (u + c - \bar{d} - \bar{s}), \\ F_2^{\nu/\bar{\nu} p(NC)} &= 2x \left[(u_L^2 + u_R^2) (u^+ + c^+) + (d_L^2 + d_R^2) (d^+ + s^+) \right] \\ xF_3^{\nu/\bar{\nu} p(NC)} &= 2x \left[(u_L^2 - u_R^2) (u^- + c^-) + (d_L^2 - d_R^2) (d^- + s^-) \right] \end{aligned}$$

Precise determination of Quark Flavor \implies Strange and Gravitational Form Factors?



Novel contribution to full description of the nucleon \implies nucleon tomography and solution to proton spin puzzle?



Novel Probe into the Non-Perturbative Regime!

<https://arxiv.org/pdf/2103.05419.pdf> starting on page 223